BIM to Sim

(How do I get that rich data into my simulations without re-entering?)

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Building Energy Simulation Forum
18 December 2013
Portland, Oregon
BIM?  Sim?

• **BIM – Building Information Modeling**
  – Represent building as three-dimensional objects with geometry, spatial relationships, geographic information, and quantities and properties of building components.
  – Graphic, interactive models.
  – Robust and rich source of building data.

• **Sim – Building Energy Simulation**
  – Model the energy and environmental performance of a building.
  – Often used in design and retrofit to reduce energy use and environmental impact.
Building Information Model/Modeling

• Building Information Model:
  – Digital representation of the physical and the functional characteristics of a facility. . . a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward.¹

• Building Information Modeling:
  – Using BIM software and other related software, hardware and technologies in a building information model²


Why Use Building Information Modeling?

- Fosters Early Collaboration Among Team Members
- Eases Parametric Modeling
- Enhances Building Model Quality
- Reduces Costs for Design and Construction Efficiencies
- Enables Sustainability Issues to be Considered through Design and Construction
  - Through reuse of the model for analysis
## U.S. Buildings' Energy Use

### Commercial Buildings Energy End-Uses 2012

<table>
<thead>
<tr>
<th>End-Use</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>17.1%</td>
</tr>
<tr>
<td>Space Heating</td>
<td>13.3%</td>
</tr>
<tr>
<td>Ventilation</td>
<td>8.8%</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>8.4%</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>6.3%</td>
</tr>
<tr>
<td>Office Equipment</td>
<td>4.7%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>4.2%</td>
</tr>
<tr>
<td>Computers</td>
<td>3.3%</td>
</tr>
<tr>
<td>Other Uses</td>
<td>32.3%</td>
</tr>
</tbody>
</table>

End-Use Energy: More Details are Better!

- **Total HVAC**: 59%
- **Equipment**: 28%
- **Total Lights**: 13%

**Equipment**:
- Wastewater treatment
- Hydronic system electric boiler
- Auditorium heat pump
- Classroom ventilation heat pump
- Auditorium energy recovery unit
- Classroom energy recovery unit
- Auditorium energy recovery unit
- Room Heat Pumps
- VSD Hydronic circulation pumps 1-2
- Hydronic circulation pumps 3-6
- Emergency lights
- Auditorium lights
- Indoor room lights
- Sidewalk lights
- Parking lot lights
- Emergency receptacles
- Receptacles
- PV system consumption
- Elevator
- Wastewater treatment

**Lights**:
- Auditorium lights
- Indoor room lights
- Sidewalk lights
- Parking lot lights
- Emergency lights
- Receptacles
- PV system consumption
- Elevator

**Other**:
- Pless and Torcellini. 2004.
Incorporating Relevant Data Requires Hard Work

Key Information

- Materials
- Sunlight
- Climate
- Energy
- Systems Type

- Space Use
- Lighting
- Humidity
- Codes
- Air Flow

- Water Usage
- CO₂
- Orientation
- Occupancy
- Configuration
Building Performance Simulation

• Simulation is still more art than science

• Major Issues:
  – Building data maintenance/storage throughout building life-cycle
  – Training...must train users in simulation methods not tools!
  – Tools must enable and encourage new technologies--too many technologies/systems that various tools cannot simulate

• Getting data from existing building information models (yes, BIM) is still a challenge.

• Green/sustainable design and policy are driving simulation more than energy costs (LEED, EPC)
Simulation Trends

• New tools/capabilities in established tools
  – Interoperability—IAI IFC, XML, BIM Standards
  – Visualization/VR
  – Integration—thermal, CFD, electrical, IEQ, visual
  – Risk assessment (insurance)
  – Embodied energy, LCI/LCA, toxicity of built environment
  – Emissions

• More tools, not fewer, customized to user needs

• Users continue to want more at lower effort

• WARNING! Do you know what default values you’re using?
Why Use Energy Simulation?

- Inform energy decisions from earliest phases of design through construction and into operation
- Help the design team and owner focus energy-use reduction efforts where they will be most effective
- Permit assessment of predicted performance with established benchmarks or project goals
- Size renewable energy systems and determine their likely % contribution
- Evaluate alternatives through programming, design, construction, operation—retrofit, too

- *Simulation is cheaper than constructing the wrong building!*
Traditional Simulation
Workflow Challenges

- Early design through construction documents – with increasing detail, multiple solutions
- Existing buildings with no details (maybe no drawings?)
- Manual input, data re-creation, translation → errors and omissions
- Utilizing virtual data (2-D CAD, BIM) → geometry robust, other data limited

Nall and Crawley 2011
Manual Model Creation

Paper or BIM Drawing

Analysis Results

Manual Data Re-creation and Entry
2D Workflow

2-D Drawing

Define Spaces

Energy Model

Analysis Results
BIM to Sim (In)directly

BIM Model

via gbXML, IFCs, direct

Analytical Model

Energy Model

Analysis Results
Analytical Model

- Visualize model in an analytical state
- Close gaps, create story (adding floor slab) – create closed shell geometry for analysis.
- Analyze building space adjacencies and auto-create “secondary boundary conditions” to represent surfaces which define individual spaces.
BIM to Sim(ulation)

- Translate BIM to Simulation
  - BuildingSMART IFCs (Industry Foundation Classes)
    - Any BIM software that supports interoperability, available since 2001
    - Limited to what BIM tools decide to export—typically only geometry
  - gbXML
  - Autodesk Green Building Studio
    - Web-based conversion of major BIM formats to energy simulation inputs
    - Limited coverage
    - Can require users to create their BIM drawings in structured way (may not follow designer regular workflow)

- Direct from BIM to Simulation
  - Major tools already have or are adding direct export to one or more simulation tools

- Interoperability is key to getting energy simulation mainstream. Other drivers—zero-energy buildings and green building rating systems
Direct from BIM to Sim Available Now
Demo – conceptual, 2-D, 3-D, PDF, sketch to Sim
Simulation vs. Operating Energy

• In low-energy building research, simulation shown to be critical in supporting decision-making for building design and operation

• BUT, compared to simulations, real buildings
  – use more energy
  – produce less power
  – have worse controls
  – have more occupant complaints
  – GIGO
  – Not enough information!
“Every building is a forecast. Every forecast is wrong.”

*Stewart Brand*

*How Buildings Learn*
Summary

• Building performance simulation is a powerful tool for evaluating and comparing building systems and technologies.

• Quality of simulation results only as good as the data entered: GIGO – the more data about the building and how it works the better.

• Getting data from BIM to Sim through interoperability is still a significant challenge in all BIM tools – often incomplete, blackbox defaults, insufficient for simulation.

• BIM tools need to attribute all key building components (walls of type x, roof of type y, construction information, equipment, systems, etc.) not just geometry.

• Interoperability among building software tools is still the best hope for accelerating the use of building simulation. Is there enough demand for interoperability to push the key developers?
Challenge: Provide Clients with Multiple Metrics

- Energy
- Demand
- Cost
- Water
- IEQ
- Carbon

Business
(student, occupied room, sales)
Questions?

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IBPSA-USA BEMbook wiki

- [http://bembook.ibpsa.us/](http://bembook.ibpsa.us/)

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- Knowledge areas:
  - Practitioner’s BEM Overview
  - BEM in the Project Context
  - Developing Whole Building Models
  - ASHRAE 90.1 PRM

- BEM workshops
Building Simulation Resources

- ASHRAE Fundamentals 2009, Chapter 14